MAINTENANCE OF SWIMMING POOLS IN THE SECONDARY SCHOOLS OF IOWA

An abstract of a Field Report by
Patricia A. Bloomcamp
August 1973
Drake University

The problem. It was the purpose of this study to determine whether or not the Secondary Schools of Iowa were maintaining hygienically safe swimming pools.

Procedure. After reviewing current professional literature, a questionnaire was prepared. The questionnaire was made up of items involved in adequate maintenance of swimming pools. The questionnaire was validated by maintenance personnel in nine of the colleges and universities of Iowa. After the suggestions and recommendations of the validating institutions were compiled, a revised questionnaire and letter of transmittal were sent to the forty-five secondary schools with swimming pools. Forty of the questionnaires were completed and returned.

Findings. A wide range of swimming pool maintenance procedures, ranging from pools that are very well maintained to those that illustrate careless maintenance, was observed. At the present time the majority of the swimming pools in the forty reporting schools are adequately maintained. However, the following areas deserve attention: (1) Over one-half of the maintenance personnel have not had any chemistry background; (2) There is no definite method of training maintenance personnel; and (3) The majority of the maintenance personnel do not have a true understanding of the filter system.

# MAINTENANCE OF SWIMMING POOLS IN THE SECONDARY SCHOOLS OF IOWA

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A Field Report

Presented to

The School of Graduate Studies

Drake University

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In Partial Fulfillment

of the Requirements for the Degree

Master of Science in Education

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by

Patricia A. Bloomcamp

August 1973

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TABLE OF CONTENTS

LIST OF TABLES

# CHAPTER I

## INTRODUCTION

In recent times many authorities in the field of physical education have promoted the construction of swimming pools in the schools of Iowa. Among them was LaPorte who stated:

> Swimming pools should be provided where at all possible, since swimming has been evaluated as the most significant all-round contributing activity in the entire list.
>
> All construction should conform to the standards established by the State Board of Health in a given statement.[1]

Virtually all of the larger high schools in Iowa have swimming pools, and most junior high schools have their own pools. In small communities where interested patrons have been able to convince the voters of the importance of the pool, new pools have been constructed. However, the shortage of funds and the corresponding rise in taxes have forced the possibility of a swimming pool out of several bond issues.

However, the construction of the facility is only a beginning, for the school swimming pool demands more attention than any other part of the building complex. Swimming

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[1] Wm. Ralph LaPorte, _The Physical Education Curriculum_ (Los Angeles: College Book Store, 1955), p. 46.

instructors, swimming coaches, parents of swimmers, medical attendants and the swimmers themselves are well aware of the high incidence of eye and throat irritation and ear infection involved in swimming, particularly competitive swimming, where the student often spends three hours a day in the water. Inadequate equipment and improper maintenance of said equipment must be blamed for such occurrences.

It is logical to assume that a swimmer will, at some time or other, ingest some of the water in which he is swimming. Therefore, the swimming pool water must equal or exceed bacteriological standards prescribed for drinking water. Chemical treatment of swimming pool water is the only satisfactory method for rendering it safe for human use. Thus, the main function of the pool chemist is the chemical treatment for safety. He must also be concerned with producing water which is inviting to see, non-irritating to eyes and skin, and free from taste and odor. Modern bacteriological studies confirm that water is a major vehicle for the transmission of disease. Typhoid and para-typhoid fevers are known to be transmitted by water. Dysentery, diarrhea, cholera and animal parasites, such as hookworm, are also water-borne.[1] As the number of pools has increased so have the eye, ear and throat problems. Procedures should

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[1]M. Alexander Gabrielson, _Swimming Pools, A Guide to Their Planning, Design and Operation_ (Fort Lauderdale, Florida: Hoffman Publications, Inc., 1969), p. 104.

be taken by schools with swimming pools to update their equipment and train their maintenance personnel to implement procedures to lessen the chance of infection.

## I. THE PROBLEM

*Statement of the problem.* It was the purpose of this study to determine whether or not the Secondary Schools of Iowa were maintaining hygienically safe pools. The Iowa State Department of Health states that all public or semi-public pools should be under competent supervision. The responsibility for maintenance and operation should be under one qualified person.[1]

*Purpose of the study.* Many schools, because of outdated equipment or untrained maintenance personnel, are forced to operate pools not specifically designed for the safety of the participants involved. It is the intention of this study to determine the safety of these pools and, if inadequacies are found to exist, to suggest recommendations for correction.

*Importance of the study.* It is hoped that the most important aspect of any part of the physical education program or interscholastic activity is the safety of the

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[1]State Department of Health, *Policies Governing Design, Construction, Maintenance and Operation of Swimming Pools* (Des Moines, Iowa: State of Iowa, 1963), p. 13.

participant. Persons involved in a swimming program are ever aware of this important aspect and are continually striving to improve the conditions. If, by the conclusions of this investigation, it is possible to identify hazardous and unhealthy conditions and bring them to the attention of the people who are able to rectify them, then it has been a study well worth the undertaking.

Limitations of the study. This study was limited to the methods used by the maintenance personnel in the forty reporting secondary schools of Iowa during the 1972-73 school year.

## II. DEFINITIONS OF TERMS

The following definitions of terms are essential to a proper understanding of the study:

Algae. Algae are any of a group of chiefly aquatic nonvascular plants with chlorophyll often marked by a brown or red pigment.[1]

Approved. Approved refers to those factors found acceptable for the specific use as determined by the

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[1]Noah Webster, *Webster's New World Dictionary of the American Language* (Collegiate edition, abridged; Cleveland: The World Publishing Company, 1958), p. 36.

[2]*Recessed Automatic Surface Skimmers for Swimming Pools* (Ann Arbor, Michigan: The National Sanitation Foundation, 1968), p. 2.

National Sanitation Foundation, when related to the use of the nSf seal.[1]

Backwash. Backwash is the process of thoroughly cleansing the filter media by reverse flow and removing the accumulated foreign-material from the filter system.[2]

Backwash rate. The backwash rate is the rate of application of water through a filter during the cleansing cycle expressed in the United States gallons per minute per square foot of effective filter area.[3]

Bacteria. Bacteria are any of a class of microscopic plants having round, rodlike, spiral of filamentous single-celled or noncellular bodies often aggregated into colonies or motile by means of flangella living in water and often being autotrophic, saprophytic, or parasitic in nutrition.[4]

Bacterial count. The bacterial count is obtained by taking a sample of water from a swimming pool and incubating it for twenty-four hours.

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[1] Ibid.

[2] Sand Type Filters for Swimming Pools (Ann Arbor, Michigan: The National Sanitation Foundation, 1966), p. 2.

[3] Ibid.

[4] Webster, op. cit., p. 108.

Bromine. Bromine is a chemical element applied to pool water to serve as a germicide or algaecide. As one of the halogen group, bromine is generically related to iodine and chlorine.

Chlorine. Chlorine is a primary element which at atmospheric temperature and pressure is a poisonous gas two and a half times heavier than air and is used for sterilizing water.[1]

Chlorinator. A chlorinator is a device used to feed, control, regulate the flow, and to measure the amount of chlorine gas introduced into the water being treated.

Chlorine reading. The chlorine reading indicates the amount of chlorine residual in terms of parts per million (ppm) in a sample of water as determined by a chlorine comparator test.[2]

Disinfectant. A disinfectant is any one of a number of chemical agents applied to the pool water to destroy vegetative forms of harmful micro-organisms.

Filter area. The effective filter area is that portion of the filter surface that will operate at the

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[1]Jerry Meslin, *Florida Swimming Pool Operator's Text* (Miami, Florida: Florida Swimming Pool Operators' Association, 1957), p. 132.

[2]*Ibid*.

design flow rate.[1]

*Filter cycle*. The filter cycle is the operating time between backwash cycles.[2]

*Filter, diatomite type*. A diatomite type filter is designed to filter water through a thin layer of filter aid such as diatomaceous earth, processed perlite or similar material. Diatomite filters may be of the pressure or vacuum type.[3]

*Filter element*. A filter element is any device within a filter tank designed to entrap solids.

*Filter, vacuum*. A vacuum filter is one which operates under a vacuum from the suction of a pump.[4]

*Flow rate*. The flow or filter rate is the rate of application of water through a filter during the filter cycle expressed in gallons per minute per square foot of effective filter area.

*Fresh water*. Fresh water is that which has a

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[1] *Sand Type Filters for Swimming Pools*, *op. cit.*, p. 3.

[2] *Ibid.*

[3] *Diatomite Type Filters for Swimming Pools* (Ann Arbor, Michigan: The National Sanitation Foundation, 1966), p. 3.

[4] *Ibid.*

specific conductivity less than a solution containing 6,000 ppm of sodium chloride.[1]

Maintenance. The maintenance of the pool includes the upkeep of the pool and pool equipment.

pH. The pH reading of the swimming pool water shows the relative degree of acidity or alkalinity of a water as indicated by the hydrogen ion concentration.

Residual. The residual is the disinfectant left in the swimming pool water, after the impurities initially present in the water are oxidized.

Turbidity. Turbidity is a quality indicating a cloudy, hazy appearance in pool water caused by finely divided particles suspended in the water.

## III. THE PROCEDURE

The procedure used in obtaining data for the study was to: (1) prepare a questionnaire from reviewing current pertinent available professional literature; (2) have the questionnaire validated by swimming pool maintenance personnel from the colleges and universities of Iowa; (3) compile the suggestions and recommendations of the validating institutions; and (4) send the questionnaire and

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[1] *Sand Type Filters for Swimming Pools*, *loc. cit.*

letter of transmittal to the forty-five secondary schools with swimming pools. The material was collected between December of 1972 and March of 1973.

The questionnaire was made up of items involved in adequate maintenance of swimming pools. Upon the return of the questionnaires the data was tabulated and analyzed. The conclusions and recommendations will be found in Chapter IV of this study.

# CHAPTER II

## LITERATURE PERTAINING TO SWIMMING POOL OPERATION AND MAINTENANCE

A review of significant literature in the area of swimming pool operation and maintenance is presented in this chapter.

*History of swimming facilities*. Although great strides have been made in swimming pool maintenance in recent years, such practices are not new. The ancient Egyptians, Greeks and Romans treated water to make it safe for human consumption, as it must be for swimming also. These antiquarians were using vegetable materials, salt and copper to treat water centuries prior to the time when disease was found to be related to impure water.[1]

The modern swimming pool era dates back to the 1920's. During that decade there were several thousand swimming pools in the United States. The public schools and other public organizations operated approximately two-thirds of the swimming pools in this country.[2] The colleges pioneered

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[1] M. Alexander Gabrielson, *Swimming Pools, A Guide to Their Planning, Design and Operation* (Fort Lauderdale, Florida: Hoffman Publications, Inc., 1969), p. 104.

[2] *Ibid*., p. 12.

in building swimming pools; later they were followed by secondary and elementary schools.

There was a phenomenal increase in the construction of swimming pools during the 1950's.[1]

Although sanitation was practiced prior to the 1950's, makeshift equipment was the order of the day. Swimming pool maintenance personnel were using equipment that had originally been designed for sewage plants or the bottling industry.[2]

During the 1950's and early 1960's high rate, single media sand filters, pressure and vacuum diatomaceous earth filters and cartridge filters were introduced for cleaning swimming pools. These innovations were designed especially for the modern swimming pools.[3]

The first diatomite filter was constructed in Hollywood for the motion picture industry so clear underwater pictures could be taken.[4] Along with the improvements in filtration there was a corresponding revolution in the use

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[1]Mildred J. Barnes and others, Sports Activities for Girls and Women (New York: Appleton-Century-Crofts, 1966), p. 322.

[2]Gabrielson, loc. cit.

[3]Ibid., p. 13.

[4]Jerry Meslin, Florida Swimming Pool Operator's Text (Miami, Florida: Florida Swimming Pool Operators' Association, 1957), p. 117.

of swimming pool chemistry. In the 1960's the dangerous gaseous chlorine and elemental bromine could be replaced with such products as iodine, chlorine in tablet form, both chlorine and bromine in stick form and chlorinated cyanurates.[1]

Development of swimming activities. The addition of thousands of swimming pool facilities to schools across the country fostered the development of new water related programs. No institution any longer was confined to the American Red Cross Learn to Swim Program.

Instruction, with an emphasis on water safety, was and still is the number one priority. Programs such as competitive swimming and diving for boys and girls, water polo, synchronized swimming, Life Saving and Water Safety within the school day are offered. During the evening and Saturday swimming instruction some of the above-mentioned programs are repeated for grade school and junior high school youngsters in Iowa. The adult education program, infant swimming, community recreational swimming, skin and scuba diving programs are also conducted during evenings and on Saturdays.

The swimming pool time is scheduled so tightly that in many cases the one and only area of the physical education program in which the physically handicapped can

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[1]Gabrielson, loc. cit.

participate is omitted. Therapeutic work and programs for the physically and mentally handicapped can be rewarding experiences for the youngsters as seen in the Special Olympics sponsored by the Kennedy Foundation yearly.

The expansion of these programs means that the maintenance personnel has a variety of needs to meet. The competitive swimmer will complain because his eyes burn from the chlorine, the instructor of the infants' program will complain because the water is too cold, and the administration will complain when the water takes on a green color.

Swimming pool health standards. If the pool is going to be a sanitary place, a number of people must do their part. Sanitation requirements prior to bathing should be established and enforced. The patrons of the pools must take it upon themselves to follow rules whether or not they are enforced by pool personnel.

The relative value of showers is discussed by the Conference for National Cooperation in Aquatics. It is felt that showers can be helpful in reducing general and coliform bacteria. Problems with filtration can be lessoned if body oil, hair oil and cosmetics are removed. The effectiveness of the chlorine is also bolstered if all forms of organic matter are removed, thus minimizing chlorine's wasteful reactions with organic matter.[1]

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[1] Report of the Eleventh Annual Meeting of Conference for National Cooperation in Aquatics (Washington, D.C.: Conference for National Cooperation in Aquatics, 1961), p. 91.

Robertson has summarized a listing of "Rules of Sanitation for Swimming Safety" as shown below:

1. Never swim while having any type of contagious disease infection.

2. To avoid contaminating a pool, a cleansing shower should be taken in the nude using warm water and soap, before entering the pool. The water in most pools is kept clean and sanitary so every effort should be made to keep it so.

3. Bathing caps should be worn in all pools by men and women with long hair.

4. Pollution of water by spitting, spouting, or blowing the nose should be carefully avoided. Never spit on the runways or where it may be tracked into the pool.

5. If you must leave the pool to go to the toilet or for any other reason, you should take another shower with soap and water before returning to the pool.

6. Use the chemical footbath before entering the pool and after taking your final shower after you have finished swimming.[1]

There seems to be a difference of opinion among the authors regarding the footbath. It is doubtless that if it is not properly attended to, it could do more harm than good. Michael argued that footbaths which consisted of a reservoir filled with a disinfectant should be replaced by a fast flow through foot bath, only to wash off debris.[2]

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[1] David H. Robertson and Charles W. Russell, Swimming (New York: Sterling Publishing Company, Inc., 1966), p. 95.

[2] Jerrold M. Michael, Training Manual for Swimming Pools, Disease Control through Proper Design and Operation (Washington, D.C.: Department of Health, Education and Welfare, 1959), p. 108.

Fox argued in favor of the use of bathing caps. She further pointed out that the use of caps minimized hair in filters and drains and that bathing caps aided in swimming comfort and safety by keeping hair out of eyes. Their use also minimized the soaking of wax in the ear and therefore reduced discomfort and the possibility of ear infection.[1]

Maintenance of equipment and facilities. The swimming pool maintenance personnel play a primary role in all facets of the swimming program. Fish believed that the swimming pool personnel must be concerned at all times with two factors, the health and comfort of the swimmers. Unless these requisites are met, any prescribed swim program will fail. He pointed out that the very efficiency of the filter system for removal of viral and bacterial particles was dependent upon the maintenance which it received by the pool operator.[2] He also felt that the maintenance of the chemical agents was the significant barrier in the disease transmission in pools.[3]

According to the Health Department of the State of Iowa, the recirculation and treatment equipment should be operated in a manner that will maintain bacterial safety

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[1]Barnes, op. cit., p. 324.

[2]N. A. Fish, "The Significance and Control of Microbiological Hazards in Swimming Pools," Canadian Journal of Public Health, LX (July, 1969), 280.

[3]Ibid., p. 281.

and physical clarity at all times. Further, it is stipulated that twenty-four hour recirculation and treatment of the water be maintained.[1]

The maintenance of constant recirculation was also recommended by Gabrielson. He felt that the significance of turnover is not properly understood by most maintenance personnel. Yet, this must be maintained to keep the pool water at necessary sanitary levels, free from turbidity and harmful organisms. Pumps must be in constant operation for the implementation of this standard.[2]

If a rate of flow indicator were provided, as the National Swimming Pool Institute stipulated, the understanding of flow rate would be greatly enhanced.[3]

The Amateur Athletic Union has even changed its ruling on pool conditions. In 1964 it stated that the pool circulating system should be turned off during meets.[4] In 1972 the

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[1]State Department of Health, Policies Governing Design, Construction, Maintenance and Operation of Swimming Pools (Des Moines, Iowa: State of Iowa, 1963), p. 13.

[2]Gabrielson, op. cit., p. 101.

[3]Suggested Minimum Standards for Residential and Public Swimming Pools (Washington, D.C.: National Swimming Pool Institute, 1969), p. 15.

[4]Rules for Competitive-Swimming, Diving and Water Polo (New York: Amateur Athletic Union, 1964), p. 22.

Union changed the statement to read as follows:

> The pool circulating system should be turned off during the swimming event, if in the opinion of the Referee, the consultant water movement interferes with the conduct of the competition.[1]

The Conference for National Cooperation in Aquatics stipulated that proper operation of both diatomite and sand filters was the most significant factor in the success of the program.[2]

Kiphuth noted that with the knowledge concerning efficient pool operation available at the present time, the water in all pools should be practically colorless and the correct chemical content be maintained at all times.[3]

Meslin called the pool an "oversized bathtub" that absorbed the external dirt and internal discharges of all its bathers. If such a pool were to be a source of infection depended first and foremost on the pool operator and the Department of Health.[4]

The National Swimming Pool Institute contended that upon completion of any swimming pool the builder should provide the manager with complete instructions for all

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[1] Rules for Competitive Swimming (Indianapolis, Indiana: Amateur Athletic Union, 1971), p. 18.

[2] Report of the Eleventh Annual Meeting of Conference for National Cooperation in Aquatics, op. cit., p. 90.

[3] Robert J. H. Kiphuth, Swimming (New York: The Ronald Press Company, 1942), p. 24.

[4] Meslin, op. cit., p. 25.

equipment and operational guidelines for maintenance of the swimming pool water.[1] A fully illustrated manual should also be provided.[2]

The importance of swimming pool maintenance is summarized by Fish as follows:

> A number of complex factors are involved in the control of microorganisms in swimming pools. Control requires vigilance and adequate supervision by competent pool operators who are knowledgeable about pool conditions and environment. A recognized acceptable pool operation to eliminate organisms must be conducted, in order that the swimming pool will serve as a healthful recreational area for the community.[3]

The State of Florida has taken steps to insure good swimming pool maintenance. They have a certification system whereby an operator is classified as a beginner, advanced or master operator. The District of Columbia has a training school for pool operators. However, there is nothing done universally to train operators.[4]

*Swimming pool filter systems.* All filter systems can be classified into two categories, the first being pressure

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[1] *Suggested Minimum Standards for Residential and Public Swimming Pools*, *op. cit.*, p. 13.

[2] *Ibid.*, p. 8.

[3] Fish, *loc. cit.*

[4] *Report of the Eleventh Annual Meeting of Conference for National Cooperation in Aquatics*, *op. cit.*, p. 38.

conditions and the second filter media.

Pressure filters are those in which a closed tank contains the filtering element. The influent is forced through the filter under pressure. As the filter becomes progressively plugged on the influent side, unless there is an automatic control, the flow rate will also be reduced, until the filter is backwashed. Pressure filters are used for granular elements and also with diatomaceous earth. Pressure filters are permitted application rates of 2.0 to 3.0 gallons per minute per square foot of filter surface.[1] According to the Iowa State Health Department the maximum rate should be 4.0 gallons per minute per square foot of filter area.[2]

Vacuum type filters are limited almost exclusively to diatomaceous earth. The influent is drawn through the diatomaceous earth septum which is connected to the suction side of the pump.

Vacuum diatomaceous earth filters are usually equipped for 1.0 to 1.8 gallons per minute per square foot of effective filter area.[3] According to the Iowa State Health Department, the maximum filtration rate should be three

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[1]Gabrielson, op. cit., p. 97.

[2]State Department of Health, op. cit., p. 8.

[3]Gabrielson, loc. cit.

gallons per square foot per minute.[1]

The media common to most pools is sand and diatomaceous earth. Lower flow rates than earlier proposed have made diatomite filters more desirable than in the past.[2]

Ideally, of course, the "flow-through" pool operations would be best suited but the cost is prohibitive. Consequently, the recirculation of water accompanied by filtration with a diversion of waste and its replacement with fresh water is the course to follow.[3]

Disinfection of the swimming pool water. It is appropriate at this point to discuss the three primary disinfectants used in swimming pools--chlorine, bromine and iodine, all members of the halogen family.

The amount of chemical needed to react with all impurities is called the demand. The residual is the excess remaining when the demand has been met. The residual is measured in parts per million (ppm) by weight.

Chlorination is the most common form of disinfection. Chlorine can be added to the water in a number of forms. When gaseous chlorine is added to the pool water two acids

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[1]State Department of Health, op. cit., p. 7.

[2]Report of the Eleventh Annual Meeting of Conference for National Cooperation in Aquatics, op. cit., p. 89.

[3]Fish, op. cit., p. 280.

are formed. The hypochlorous acid is very unstable, but releases free chlorine to act on the impurities of the water.[1]

Calcium hypochlorite Ca (OCL) is a dry white compound sold commercially in granular or tablet form. It is easier and safer to handle than the cheaper gas, but it is a strong oxidizing agent and can ignite if not properly handled.

Sodium hypochlorite (NaOCL), another disinfectant, which can be fed through a hypochlorinator or by hand, is sold in a clear liquid form. Cyanurates, which are chlorine compounds of cyanuric acids, cost a great deal and consequently are not often used in school pools.[2]

Breakpoint chlorination experiments have found it to be advantageous for pools which have a high organic content for controlling algae and eliminating chlorine odors, tastes and eye irritation. Breakpoint chlorination is based upon the following principle. When chlorine is added to the pool water, it is immediately absorbed by organic matter in the pool. Chloramines and other compounds are formed. When the demand is met, the addition of small amounts of chlorine in excess will result in a free residual chlorine. However, if greater amounts of free residual are added there comes a point at which it begins to oxidize the combined chlorine

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[1]Gabrielson, _op. cit._, p. 105.

[2]_Ibid._, p. 106.

compounds. Since these compounds use a high excess of free chlorine, the residual falls suddenly to a much lower point and the chlorine compound disappears. Because a great part of the so-called "chlorine odors" and tastes come from combined chlorine, these ill effects will also disappear. The breakpoint is the point at which this oxidation of chlorine compounds begins. Most of the chlorine in the water will be in a free state if sufficient chlorine is added to pass the breakpoint.[1]

In studying the effects on bacterial flora treated with high-free residual chlorine, Robinton and others found that the high-free chlorine residual minimized bacterial density. These authors also discovered that the residual was easy to maintain regardless of swimming load.[2]

Chlorine does have definite disadvantages although it is widely used. Numerous complaints from bathers indicate that even in concentration less than 1.0 ppm a considerable amount of irritation is found in the mucous membranes.[3] This irritation may be caused from nitrogen trichloride. The

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[1]Ibid., p. 107.

[2]Elizabeth Robinton, Eric W. Mood and Louise R. Elliot, "A Study of Bacterial Flora in Swimming Pool Water Treated with High-free Residual Chlorine," American Journal of Public Health, XLVII (September, 1957), 1109.

[3]J. R. Brown and others, "Bromine Disinfection of a Large Swimming Pool," Canadian Journal of Public Health, LV (June, 1964), 251.

addition of chlorine in an amount sufficient to destroy ammonia and other nitrogenous compounds present in the water causes such a formation. Black enumerated the disadvantages of chlorine. According to him, after breakpoint, within the preferred pH range, monochloramines are present. Numerous investigators have proven the ability of chloramines to be far inferior to free available chlorine in killing bacteria. The statement commonly made is that free chlorine is approximately thirty times as effective as chloramines in bacterial efficiency. The bactericidal efficiency of chlorine steadily decreases as the pH increases.[1]

Brown argued that bromine was just as effective as chlorine in its viricadal and bactericidal activity and also was considerably less irritating to the mucous membranes. He further added that bromamines also had a high sterilizing activity whereas chloramines are generally ineffective in this area.

A study of the effects of bromine was conducted by Brown and others in a large, frequently patronized pool over a period of twenty-seven weeks from February to August, 1963. In this particular study no odors or ill effects were noted even when the bromine residual exceeded 4 ppm.[2] There was

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[1]A. P. Black, James B. Lackey and Elsie Wattie Lackey, "Effectiveness of Iodine for the Disinfection of Swimming Pool Water," American Journal of Public Health, IL (August, 1959), 1060.

[2]Brown and others, op. cit., p. 255.

relatively slight evidence of bacterial contaminations from coliforms, enterococci, streptococcus viridans or staphylococci, when the bromine residual was maintained above 2 ppm. No virus was isolated from water samples taken.[1]

In a publication by the Iowa State Health Department the use of bromine was not recommended unless a six-hour turnover or less was provided and the pool design lent itself to the highest degree of sanitation, the reasoning behind this being that bromine was so active on organic wastes and an excessive amount was required to maintain a satisfactory residual.[2]

Gabrielson pointed out that the handling of bromine can be dangerous. Bromine fumes are highly irritating to the eyes and lungs and bromine will blister skin.

Bromine is used mainly in the liquid state but one company has a dry solid compound. When using this compound one city school district was very pleased with it, but has had to install an elaborate system of manifolds and valves to control the residual properly.[3]

Chlorine is first on the list of frequency; bromine is second and iodine third. In studying the effectiveness

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[1] *Ibid.*, p. 256.

[2] State Department of Health, *op. cit.*, p. 10.

[3] Gabrielson, *op. cit.*, p. 108.

of iodine as a disinfectant for swimming pools, Black and others found it to be more effective than chlorine. This study was placed at seven pools in Gainesville, Florida, and one in Coral Gables, Florida. These authors used potassium iodide and added chlorine to release free iodine.[1] When this was done a dark brown cloud developed at these points where iodine was released.[2] At a later time, with swimmers in the pool, the cloud quickly and uniformly disseminated throughout the water. When the manual method of application was replaced by the addition of iodine through the pool circulating system no such color or cloud appeared. Further investigation provided an absence of odor and eye irritation. A much smaller applied dosage than that of chlorine was needed to maintain the desired residual. These iodine residuals seemed to be much less dependent on bathing load since iodine is not affected by ammonia introduced by bathers.[3]

Byrd and others are other proponents of iodine. In their opinion, iodine was safe, effective and superior to chlorine in regard to reducing physical discomfort and irritation. These authors conducted a study at Stanford

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[1] Black and others, op. cit., p. 1060.

[2] Ibid., p. 1065.

[3] Ibid., p. 1066.

University and found no evidence of inhalation, ingestion or absorption of iodine by thirty male swimmers who swam in three outdoor pools for one month. He observed no conjunctivitis in twenty-seven swimmers and only one minor eye irritation. Among the twenty swimmers, seventeen preferred iodine over chlorine as did forty-eight out of fifty-three participants in a intercollegiate swimming meet.[1] Later these swimmers were found capable of studying at night as they were free from irritation of the eyes.[2]

Fish observed that iodine had a unique property. The active disinfectant, free iodine, constantly was regenerated and it was easy to maintain. The only disadvantage was that pseudomonas alcaligenes and alcaligenes faecalis are iodine resistant.[3]

However, Gabrielson pointed out two disadvantages of iodine. In reality, it was more expensive because chlorine was used to release the iodine and it was difficult to control the pH and iodide ion.[4] It was the consensus of the above-mentioned writers that iodine's primary advantage was the reduction in eye irritation. Individuals' eyes do differ in their sensitivity to water pressure, impurities

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[1]Oliver E. Byrd and others, "Safety of Iodine as a Disinfectant in Swimming Pools," Public Health Reports, LXXVII (May, 1963), 397.

[2]*Ibid*., p. 396. [3]Fish, *op. cit*., p. 281.

[4]Gabrielson, *op. cit*., p. 109.

and chemicals, but need to be open for "convenience, balance, orientation and safety."[1]

Experiments have also been conducted with some silver compounds such as argerol and silver nitrate and ultraviolet radiation for disinfection, but have not as yet proved practical.[2]

Maintenance of the pH of swimming pool water. Gabrielson argued that in reality the great majority of eye irritation and complaints were not due to chlorine at all, but rather due to low pH or dissolved alum in the water. The addition of soda ash (sodium carbonate, $Na_2 CO_2$) to the water can control pH. Another most commonly practiced method was to add small quantities of sodium bisulfate (sodium acid sulfate, NaHSO) to the water or add small quantities of hydrochloric (muriatic) acid to the water. The latter is not recommended for common use because of the danger involved in handling the substance. A person with a chemistry background is best qualified to handle such substance.[3]

Hydrochloric acid, one of two acids formed when gaseous chlorine is added to the water, lowers the pH of

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[1] Swimming and Water Safety Textbook (Washington, D.C.: American National Red Cross, 196?), p. 17.

[2] Gabrielson, loc. cit. [3] Ibid., p. 110.

the water and must be neutralized. Neutralization of the water is accomplished by the addition of 1.25 to 1.5 pounds of soda ash per pound of chlorine used.[1]

Testing of swimming pool water. Testing of swimming pool water for chlorine and pH content is accomplished by using a laboratory prepared color sample.

When testing for chlorine residual an empty vial is filled with water and orthotolidine is added with an eye dropper to the vial. The reading is taken immediately by comparing the color of the sample with the prepared sample. Residual bromine can be tested very easily with the same colorimeter test kit. However, the reading must be doubled.[2]

According to the Iowa State Health Department the equipment should be provided to apply chlorine continuously so as to maintain a chlorine residual of .4 to 1 ppm in the pool water at all times or a bromine residual of .2 to .5 ppm.[3]

Gabrielson agreed with the authorities who advocated a constant residual of .6 to 1 ppm of free chlorine or 1.5 to 2 ppm combined chlorine.[4]

The pH, or measure of acidity of a solution, is listed on a scale of one to fourteen. According to the measurements

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[1] Ibid., p. 105. [2] Ibid., p. 110.

[3] State Department of Health, op. cit., p. 60.

[4] Gabrielson, op. cit., p. 105.

on this scale distilled water contains a pH of 7.0. In America most states recommend a pH of 7.2 to 7.6.[1]

In testing for pH, the three most commonly used dyes are: phenol red, bromthymol blue, and cresol red. A separate set of color standards and indicator dye are used in the same colorimeter.[2]

In summarizing the importance of maintaining the pH of the pool water it should be pointed out that experiments in breakpoint chlorination indicated that up to 5.0 ppm will not irritate eyes or bleach suits if the pH is maintained at 8.0 or over.[3]

The Iowa State Health Department has recommended that pH of 7.2 to 7.6 should be maintained and also it recommended testing the pool water at least four times a day. Regular bacteriological examinations should be made at least once a week, or more often if possible.[4]

Testing is complicated and time consuming. A water sample is incubated for twenty-four hours in a nutrient lactose broth and in agar. This test will indicate the presence of bacteria in a given sample. If the total bacterial count is very low (below 50) and if no gas is formed which indicates

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[1]Ibid., p. 110. [2]Ibid., p. 111.

[3]Ibid., p. 107.

[4]State Department of Health, op. cit., p. 13.

the presence of disease carriers there is no need for further testing. If a high bacterial count is found, another twenty-four hour period is allowed for the presence of possible harmful bacteria to be determined. If no gas is formed in forty-eight hours, the water is considered safe. If the formation of gas is detected further tests are necessary.[1]

Although the tests are time consuming they are very essential as numerous bacteria may be present in swimming pool water and the environs. Dick conducted an in-depth study in seven outdoor pools located in the Kansas City, and Topeka, Kansas, areas in 1958.[2] He sampled both surface and subsurface bacteria and found in both the areas upper respiratory bacteria such as alpha-hemolytic streptococci, neisseria and micrococci. Micrococci, both hemolytic and nonhemolytic were most frequently encountered. Coliforms were rarely found.[3]

Almost all average surface or subsurface counts fell within the American Public Health Association "fair" standard. This means there were between 200 and 1,000 bacteria per ml. There were three times as much bacteria on the surface.[4]

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[1] Gabrielson, _op_. _cit_., p. 104.

[2] Elliot C. Dick, Ivan F. Shiell and Alan S. Armstrong, "Surface - Subsurface Distribution of Bacteria in Swimming Pools - Field Studies," _American Journal of Public Health and the Nation's Health_, L (May, 1960), 691.

[3] _Ibid_., p. 692.

[4] _Ibid_., p. 694.

Swimming pools serve as a source of human microbiological infection. In Washington, D.C., in 1954, and Toronto, Canada, in the summer of 1955, acute viral infections such as pharynogoconjunctival fever affected numerous bathers. Parainfluenza viruses were also discovered in swimming pools.

Members of the streptococcal species and in particular streptococcus fecalis and streptococcus viridans may also be isolated. Streptococcus fecalis is classified in the group of pathogenic entero-bacteria associated with gastrointestinal infections. Inadequate sterilization of oronasal secretions which may contain other pathogenic organisms including diphteroids is indicated by the presence of Streptococcus viridans. Staphylococcus aureus, a source of pyodermal infections that may be harbored in the oronasal secretions, is also prevalent.[1]

In the area around the improperly managed swimming pools the two predominant groups are mycotic and viral. This includes Epideimophyton and the Trichophyton species. The latter produces "athlete's foot." The papiloma virus is the inciting agent of "plantar's warts."[2] Other waterborne diseases carried by human excreta include cholera from the vibrio cholera organism, Typhoid Fever from

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[1]Fish, _op. cit._, p. 279.

[2]_Ibid._, p. 280.

Eberthella typhosa, Paratyphoid Fever from Salmonella paratyphi, Bacillary dysentery from Shigella dysenteria, and Hepatitis from Hepatitis virus.[1]

Ear canal infections (otitis media, otitis externa) were found by Campbell to occur normally in 1.4 per cent of bather population in Maryland in 1959 and 1960.[2] Armbruster believed that the swimmer was more susceptible to the common cold than any other athlete.[3]

Algae control in swimming pools. Factors that are important to the growth of algae are temperature, sunlight, pH, bacteria and mineral content of the water. The problem of controlling algae growths in swimming pools is very complex as there are forty-six species of "clean water" algae.[4] The problem is more acute in outdoor pools than indoors.

Meslin contended that there was no evidence that algae are responsible for human disease, but it made the

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[1]Meslin, op. cit., p. 15.

[2]W. Campbell and others, "Iodine - New Disinfectant for Your Swimming Pool," Journal of Health, Physical Education and Recreation, XXXII (May - June 1961), 72.

[3]David A. Armbruster, Robert H. Allen and Hobert Sherwood Billingslay, Swimming and Diving (fourth edition; St. Louis: The C. V. Mosby Company, 1963), p. 201.

[4]Gabrielson, op. cit., p. 114.

water an unattractive shade of green, decreased water clarity, increased chemical demand, promoted bacteria growth, created a slipping hazard and imparted objectionable odors.

The three types of algae associated with the swimming pool are first the free-floating algae which make the water look murky green. It is caused by insufficient filtration, low chemical residual or channeling in the filter. It can be corrected by continuous filtration, super-chlorination and filter inspection.

The second is bottom algae. This settles on the floor, creating sediment. Causes for such occurrences are improper filtration, insufficient brushing and turbid water which are treated by continuous filtration, frequent brushing and a high chlorine residual.

The last is sessile algae, which grows in filaments on walls and floors. Strong sunlight, high water temperatures and insufficient brushing aid in the growth of sessile algae. Suggested treatment is draining, brushing and drying of the pool.

Chemical treatment for algae includes the adding of copper sulfate or quaternary ammonium compounds.[1] Whereas copper sulfate is not effective in highly alkaline water and tends to dye hair and suits, it does tend to reduce the

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[1]Meslin, op. cit., p. 12.

ammonia content in water.[1]

Swimming pool water temperature. A number of different recommendations have been made in regard to the ideal water temperature.

The following table shows the range of recommended water temperature for swimming pools:

RECOMMENDED SWIMMING POOL WATER TEMPERATURES

| Temperature | Source of Recommendation | Comment |
|---|---|---|
| 70 - 78° | Amateur Athletic Union | 1964[2] |
| 70 - 78° | American Red Cross | Most inviting[3] |
| 72 - 75° | Kiphuth | Instruction and Competition[4] |
| 72 - 78° | American Red Cross | All-round use[5] |

[1]State of Illinois Department of Public Health, Swimming Pool Operation (Chicago: Sterne and Maley Company, 1948), p. 43.

[2]Rules for Competitive-Swimming, Diving and Water Polo (New York: Amateur Athletic Union, 1964), p. 22.

[3]American Red Cross, Lifesaving and Water Safety (Garden City, New York: Doubleday and Company, Inc., 1956), p. 4.

[4]David L. Costill, "Effects of Water Temperature on Aerobic Working Capacity," Research Quarterly, XXXIX (March, 1968), 67.

[5]Instructor's Manual - Swimming and Diving Courses (Washington, D.C.: American Red Cross, 1968), p. 12.

RECOMMENDED SWIMMING POOL WATER TEMPERATURES
(continued)

| Temperature | Source of Recommendation | Comment |
|---|---|---|
| 76 - 78° | American Red Cross | Reasonable[1] |
| 76 - 78° | National Collegiate Athletic Association | 1966[2] |
| 76 - 80° | National Collegiate Athletic Association | 1971 for competition[3] |
| 78 - 80° | Amateur Athletic Union | 1972[4] |
| 78 - 82° | American Red Cross | Teach beginners[5] |
| 80° | Sports Illustrated | Beginners[6] |

[1]American Red Cross, Swimming and Diving (Garden City, New York: Doubleday and Company, Inc., 1938), p. 13.

[2]David L. Costill, "Effects of Water Temperature on Aerobic Working Capacity," The Research Quarterly, XXXIX (March, 1968), 67.

[3]Vic Gustafson (ed.), Official National Collegiate Athletic Association Swimming Guide (Phoenix, Arizona: College Athletics Publishing Service, 1971), p. 11.

[4]Rules for Competitive Swimming (Indianapolis, Indiana: Amateur Athletic Union, 1971), p. 139.

[5]Instructor's Manual - Swimming and Diving Courses (Washington, D.C.: American Red Cross, 1968), p. 11.

[6]Matt Mann (ed.), Sports Illustrated Book of Swimming (Philadelphia and New York: J. B. Lippincott Company, 1961), p. 10.

A number of considerations should be made in adjusting the water temperature. There is considerable variation in human tolerance to cold. The weather conditions and the swimmer's body type will affect the tolerance. High humidity keeps the body from cooling by itself.[1]

In conjunction with testing the water temperature, Meslin has pointed out the necessity of testing for humidity, suggesting that many times, as odd as it may seem, the heat and ventilating systems of the pools do not provide the humidity compatible with health.[2] Colds can be induced by an absence of proper amount of moisture in the air, irritating the respiratory tract.[3]

New innovations in swimming pool maintenance equipment. The future may see the use of automatic filtration which is sensitive to pressure differentials or changes in flow rates and automatically goes into backwash. This has been developed in both the United States and England. At the present time this device is very dependent upon sophisticated instrumentation and is quite expensive. Experiments in electronic and ultrasonic filtration have indicated a

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[1]Virginia Hunt Newman, Teaching an Infant to Swim (New York: Harcourt, Brace and World, Inc., 1967), p. 37.

[2]Meslin, op. cit., p. 24.

[3]Ibid., p. 25.

possibility of their use.[1]

Cleaning will be facilitated by automatic cleaning systems. These sweep debris to the main drains by jet pressure utilizing hoses or "jet" inlets and some actually vacuum the pool bottom and collect debris without sending it through the filter. Chemical feeding may be simplified by chlorine and pH solution feeders which constantly test the water and feed according to demand.[2]

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[1]Gabrielson, op. cit., p. 193.

[2]Ibid., p. 194.

# CHAPTER III

## PRESENTATION AND ANALYSIS OF DATA

It will be proper at this point to present data concerning maintenance, health and safety conditions in swimming pools of secondary schools in Iowa.

The information was provided by responses to a questionnaire sent to forty-five junior and senior high school swimming coaches, or swimming instructors, who distributed them to the persons directly responsible for the maintenance of the swimming pools in their respective schools. Accordingly, these responses were received from forty maintenance personnel out of forty-five questionnaires.

Background of schools and maintenance personnel surveyed. Table I indicates the persons responsible for maintaining the pool. The responses indicate that there is a person directly responsible for the pool in twenty Iowa schools. However, of these twenty, ten are head custodians.

Nine respondents reported other job descriptions which include: assistant head custodian, building engineer, girls' physical education instructor, swimming instructor, general building maintenance man, supervisor of operation and maintenance, and senior high school operating and maintenance engineer.

TABLE I

RESPONSIBILITY FOR SWIMMING POOL MAINTENANCE REPORTED BY MAINTENANCE PERSONNEL IN FORTY SECONDARY SCHOOLS IN IOWA

| Job Description | Number of Maintenance Personnel | Per Cent of Schools |
|---|---|---|
| | (N = 40)* | |
| Building Principal | 1 | 2.5 |
| Coach (swimming) | 6 | 15 |
| Head Custodian | 18 | 45 |
| Pool Maintenance | 20 | 50 |
| Other | 9 | 22.5 |

*This figure totals more than forty due to multiple responses.

The data in Table II show that seventeen or 42.5 per cent of the maintenance personnel learned the operation of the pool from other school building operators. This table also indicates that 27.5 per cent of the maintenance personnel were given no specific training for the job. Twenty-one of the personnel reported that they had no chemistry background; one reported one-half year's experience; fourteen reported one year's experience; two reported three years' experience; and only one reported more than three years' instruction in this science.

TABLE II

TRAINING OF SWIMMING POOL MAINTENANCE PERSONNEL IN FORTY IOWA SECONDARY SCHOOLS

| Training | Maintenance Personnel Number | Maintenance Personnel Per Cent |
|---|---|---|
| | (N = 40)* | |
| Professional Engineer | 7 | 17.5 |
| Manufacturer | 6 | 15.0 |
| Installer | 7 | 17.5 |
| School Personnel | 17 | 42.5 |
| None | 11 | 27.5 |

*These figures total more than forty due to multiple responses.

Table III indicates that one-half of the respondents have had from six to fifteen years' experience in the field of swimming pool maintenance.

Table IV shows that fifteen, or 37.5 per cent of the pools have been in operation five years or less and that 50 per cent of the pools were built six to fifteen years ago.

Eighteen of the maintenance personnel reported that they never swim in the pool themselves; eight swim daily;

TABLE III

YEARS OF EXPERIENCE OF SWIMMING POOL MAINTENANCE PERSONNEL IN FORTY IOWA SECONDARY SCHOOLS

| Experience | Maintenance Personnel Number | Per Cent |
|---|---|---|
| Less than 1 year | 6 | 15 |
| 1 to 5 years | 9 | 22.5 |
| 6 to 10 years | 16 | 40 |
| 11 to 15 years | 4 | 10 |
| More than 15 years | 5 | 12.5 |

TABLE IV

YEARS OF SWIMMING POOL OPERATION IN FORTY IOWA SECONDARY SCHOOLS

| Number of Years in Operation | Number of Schools | Per Cent of Schools |
|---|---|---|
| Less than 1 year | 3 | 7.5 |
| 1 to 5 years | 10 | 25 |
| 6 to 10 years | 6 | 15 |
| 11 to 15 years | 5 | 12.5 |
| More than 15 years | 16 | 40 |

three swim weekly: six swim monthly; and four swim annually. One reported that he swam "once in a while."

Table V shows that some schools conduct swimming classes and only eight, or 20 per cent, provide time for therapeutic work. The majority of the schools also have competitive, synchronized and recreational swimming available.

TABLE V

ACTIVITIES CONDUCTED IN THE SWIMMING POOLS OF THE FORTY REPORTING SCHOOLS IN IOWA

| Activities of Schools | Number of Schools | Per Cent of Schools |
|---|---|---|
| | (N = 40)* | |
| Instruction | 40 | 100 |
| Competitive | 31 | 77.5 |
| Recreational Swimming | 37 | 92.5 |
| Therapeutic Work | 8 | 20 |
| Synchronized Swimming | 23 | 57.5 |

*These figures total more than forty due to multiple response.

Table VI indicates that five, or 12.5 per cent, of the schools have no sanitation enforcements prior to bathing. Thirty-five, or 87.5 per cent, require showers.

TABLE VI

SANITATION ENFORCEMENTS PRIOR TO BATHING REPORTED BY MAINTENANCE PERSONNEL IN FORTY SECONDARY SCHOOLS IN IOWA

| Sanitation Enforcement | Number of Schools | Per Cent of Schools |
|---|---|---|
| | (N = 40)* | |
| Shower | 35 | 87.5 |
| Foot Bath | 2 | 5 |
| Caps for Girls | 20 | 50 |
| Caps for Boys with Long Hair | 11 | 27.5 |
| None | 5 | 12.5 |

*These figures total more than forty due to multiple response.

Time spent in swimming pool maintenance. The data in Table VII indicate that the time spent in maintenance ranges from less than one hour per day in three schools to nine hours per day in one school; one hour per day for engineering and eight hours per day for custodial work.

Maintenance personnel are assigned to the pool ranging from one to seven days per week. Twenty-two personnel are assigned on a daily basis; six are assigned for six days: and ten are assigned for five days. In one school one person reports twice a week and in another school the maintenance man works one day a week.

TABLE VII

TIME SPENT IN MAINTENANCE OF THE SWIMMING POOLS IN THE FORTY REPORTING SECONDARY SCHOOLS OF IOWA

| Time in Hours | Number of Schools | Per Cent of Schools |
|---|---|---|
| Less than One | 3 | 7.5 |
| One | 8 | 20 |
| Two | 17 | 42.5 |
| Three | 11 | 27.5 |
| Other | 1 | 2.5 |

The swimming pool floor is cleaned daily in one-half of the forty reporting Iowa schools as indicated in Table VIII. Eleven, or 27.5 per cent, of the floors are cleaned weekly and two floors are cleaned monthly. Other responses were "every other day," "twice weekly," "every two or three days," and "as needed."

Table IX indicates that a hose and a disinfectant are used most frequently for cleaning the pool deck. The majority of the maintenance personnel used a combination of devices listed in Table IX. Other responses indicated the use of "automatic scrubbing machine" and "electric buffer."

TABLE VIII

FREQUENCY OF SWIMMING POOL FLOOR CLEANING IN FORTY IOWA SECONDARY SCHOOLS

| Frequency of Cleaning of Swimming Pool Floor | Number of Schools | Per Cent of Schools |
|---|---|---|
| Daily | 20 | 50 |
| Weekly | 11 | 22.5 |
| Monthly | 2 | 5 |
| Other | 7 | 17.5 |

Thirty-three schools clean the pool deck on a daily basis, while two schools clean the pool deck three times a week and five schools clean the pool deck once a week.

TABLE IX

METHOD OF CLEANING THE SWIMMING POOL DECKS IN THE FORTY REPORTING SECONDARY SCHOOLS IN IOWA

| Method of Cleaning | Number of Schools | Per Cent of Schools |
|---|---|---|
| | (N = 40)* | |
| Hose | 26 | 65 |
| Mop | 22 | 55 |
| Brush | 5 | 12.5 |
| Disinfectant | 29 | 72.5 |
| Other | 2 | 5 |

*These figures total more than forty due to multiple responses.

Swimming pool area air circulation and temperature. Table X illustrates that thirty-six, or 90 per cent, of the personnel reporting use fans to circulate the air in the swimming pool area. All schools reported some form of ventilation of swimming pool area; out of which three were equipped with air conditioning and six used open windows. The other two responses were "open patio doors" and "unit ventilators."

In thirty-three schools the air was circulated continuously in the swimming pool area; whereas, three sources reported intermittent air circulation of the swimming pool area.

TABLE X

METHOD OF AIR CIRCULATION IN SWIMMING POOL AREA IN FORTY IOWA SECONDARY SCHOOLS

| Air Circulation Method | Number of Schools | Per Cent of Schools |
|---|---|---|
| | (N = 40)* | |
| Air Conditioning | 3 | 7.5 |
| Fans | 36 | 90 |
| Open Window | 6 | 15 |
| None | 0 | 0 |
| Other | 2 | 5 |

*These figures total more than forty due to multiple responses.

Table XI indicates the average air temperatures maintained in the various swimming pool areas. Twenty-six or 65 per cent of the swimming pool areas are heated to 80° Fahrenheit. Only two schools reported maintaining the temperature at 70° Fahrenheit in their swimming pool areas.

TABLE XI

THE AVERAGE AIR TEMPERATURE IN THE SWIMMING POOL AREA IN FORTY IOWA SECONDARY SCHOOLS

| Average Air Temperature Degrees Fahrenheit | Number of Schools | Per Cent of Schools |
|---|---|---|
| 70 | 2 | 5 |
| 75 | 4 | 10 |
| 80 | 26 | 65 |
| 85 | 8 | 20 |
| Other | 0 | 0 |

<u>Swimming pool water temperature</u>. Table XII shows data regarding the average water temperature of the swimming pools sampled. All temperatures were in the 75° Fahrenheit to 85° Fahrenheit range, out of which thirty-three, or 82.5 per cent, reported to be 80° Fahrenheit.

TABLE XII

WATER TEMPERATURE OF SWIMMING POOLS IN FORTY IOWA SECONDARY SCHOOLS

| Average Water Temperature Degrees Fahrenheit | Number of Schools | Per Cent of Schools |
|---|---|---|
| 70 | 0 | 0 |
| 75 | 4 | 10 |
| 80 | 33 | 82.5 |
| 85 | 3 | 7.5 |
| Other | 0 | 0 |

Types of swimming pool filter systems. Table XIII indicates the types of filter systems used in the pools. Three types of systems were frequently used. Fifteen of the schools reported the use of a diatomaceous earth vacuum filter system; thirteen, or 32.5 per cent, employed a diatomaceous earth pressure filter system while eleven, or 27.5 per cent, had sand pressure systems. Only one school reported owning a sand gravity filter system.

The maintenance personnel of Iowa Secondary Schools were also asked to specify the flow rate per square foot of filter area for which their pool was designed. Only thirteen personnel reported the knowledge of the system. Three schools

TABLE XIII

TYPES OF SWIMMING POOL FILTER SYSTEMS USED
BY FORTY IOWA SECONDARY SCHOOLS

| Type of Filter System | Number of Schools | Per Cent of Schools |
|---|---|---|
| Sand (Pressure) | 11 | 27.5 |
| Sand (Gravity) | 1 | 2.5 |
| Diatomaceous Earth (Vacuum) | 15 | 37.5 |
| Diatomaceous Earth (Pressure) | 13 | 32.5 |
| None | 0 | 0 |
| Other | 0 | 0 |

specified two per square foot; eight reported three per square foot; and two stated four per square foot.

Disinfection of swimming pools. The type of disinfectant used by forty Iowa schools is illustrated in Table XIV. The most frequently used disinfectant was chlorine. Its use was reported by thirty-six or 90 per cent of the schools. Two schools reported the use of bromine and one reported the use of iodine. The other response was "13% bleach."

TABLE XIV

TYPES OF DISINFECTANTS USED IN THE SWIMMING POOLS OF THE FORTY REPORTING SECONDARY SCHOOLS IN IOWA

| Types of Disinfectant | Number of Schools | Per Cent of Schools |
|---|---|---|
| Bromine | 2 | 5 |
| Chlorine | 36 | 90 |
| Iodine | 1 | 2.5 |
| Ozone | 0 | 0 |
| Other | 1 | 2.5 |

Table XIV showed chlorine as the primary disinfectant, whereas Table XV indicated a range in disinfection equipment. Gas chlorinators are used by twenty-three schools; hypochlorinators by eight schools and hand chlorination by five schools. Only two schools reported the use of brominators and one school had replied that a saturator was in use. The other response was "slurry feed."

Table XVI showed the frequency of disinfection application. Twenty-one of the respondents showed a continuous application; fourteen or 35 per cent applied the chemical daily; two applied disinfection on a twice - daily basis and one applied disinfection on a weekly basis. The other two responses were "twice weekly" and "don't know."

TABLE XV

TYPES OF DISINFECTING EQUIPMENT USED IN THE SWIMMING POOLS IN THE FORTY REPORTING SECONDARY SCHOOLS IN IOWA

| Type of Disinfecting Equipment | Number of Schools | Per Cent of Schools |
|---|---|---|
| Gas Chlorinator | 23 | 57.5 |
| Hypo-chlorinator | 8 | 20 |
| Brominator | 2 | 5 |
| Saturator | 1 | 2.5 |
| Other | 6 | 15 |

TABLE XVI

FREQUENCY OF DISINFECTANT APPLICATION IN THE SWIMMING POOLS IN THE FORTY REPORTING SECONDARY SCHOOLS OF IOWA

| Frequency of Disinfectant Application | Number of Schools | Per Cent of Schools |
|---|---|---|
| Continuously | 21 | 50.5 |
| Twice Only | 2 | 5 |
| Daily | 14 | 35 |
| Weekly | 1 | 2.5 |
| Other | 2 | 5 |

The average disinfectant residual is illustrated in Table XVII. Eighty per cent of the respondents maintained the disinfectant residual between .5 and 1; three of the other respondents maintained at 7.5 and two at 1.5. One respondent reported a 3 reading. He further explained that he knew this was not accurate but he could not get it down. Two of the respondents failed to answer the question.

TABLE XVII

AVERAGE DISINFECTANT RESIDUAL MAINTENANCE IN THE SWIMMING POOLS REPORTED BY MAINTENANCE PERSONNEL IN FORTY SECONDARY SCHOOLS IN IOWA

| Average Disinfectant Residual Maintained | Number of Schools | Per Cent of Schools |
|---|---|---|
| .0 | 0 | 0 |
| .5 | 11 | 27.5 |
| 1 | 21 | 52.5 |
| 2 | 2 | 5 |
| Other | 6 | 15 |

<u>pH maintenance of swimming pool water</u>. Table XVIII showed that average pH readings ranged from 6.6 to 8. Thirty maintenance personnel, or 75 per cent, indicated an average pH reading of 7.6; four schools reported readings of 7 and 8; one reported 6.6. One of the respondents who reported a 7 reading also indicated that he knew the reading should be higher.

TABLE XVIII

AVERAGE pH MAINTENANCE IN THE SWIMMING POOLS OF FORTY REPORTING SECONDARY SCHOOLS IN IOWA

| Average pH Maintenance | Number of Schools | Per Cent of Schools |
|---|---|---|
| 6.6 | 1 | 2.5 |
| 7 | 4 | 10 |
| 7.6 | 30 | 75 |
| 8 | 4 | 10 |
| Other | 1 | 2.5 |

Chemical adjustment of swimming pool water. The responses to the questionnaire revealed that the swimming pool water in twenty-two, or 55 per cent, of the schools is chemically adjusted daily; nine pools, or 22.5 per cent, are adjusted twice daily; two responses indicated "as needed." One respondent did not know the answer and another misinterpreted the question.

Testing of the swimming pool water. Tables XX and XXI showed the frequency of testing the swimming pool water. Table XX showed the testing of water for chlorine and pH. Table XXI showed the testing of water for bacterial count.

TABLE XIX

FREQUENCY OF CHEMICAL ADJUSTMENT OF WATER IN THE SWIMMING POOLS OF THE FORTY REPORTING SECONDARY SCHOOLS IN IOWA

| Frequency of Chemical Adjustment of Water | Number of Schools | Per Cent of Schools |
|---|---|---|
| Twice Daily | 9 | 22.5 |
| Daily | 22 | 55 |
| Twice Weekly | 2 | 5 |
| Weekly | 3 | 7.5 |
| Other | 4 | 10 |

TABLE XX

FREQUENCY OF WATER TESTING IN THE SWIMMING POOLS OF THE FORTY REPORTING SECONDARY SCHOOLS OF IOWA

| Number of Times Tested | Number of Schools | Per Cent of Schools |
|---|---|---|
| Weekly | 0 | 0 |
| Daily | 21 | 52.5 |
| Twice Daily | 12 | 30 |
| Three Times Daily | 6 | 15 |
| Other | 1 | 2.5 |

All pools were tested at least once a day to determine the pH and chlorine reading. Frequency of testing ranged from one to six times a day.

The data concerning the frequency of checking the bacterial count in swimming pools ranged from never to daily; sixteen, or 40 per cent, indicated taking a weekly count; three pools were never examined for bacterial count; two were checked twice a week; one was checked bi-monthly; another was examined four times a year and one was examined daily by local personnel and weekly by the state. Three questionnaires were left unanswered.

The bacterial count was examined by city agencies for twenty-six schools; by the State of Iowa for eight schools; the school district agency for one school; by the county health department for one school; and in another case by the University of Iowa. One of the personnel, who stated that the State of Iowa was its examining agency, pointed out that the bacterial count had been examined nine years ago.

Swimming pool problems. The responses to the questionnaire revealed many facts about problems encountered in swimming pool operation. Table XXII illustrated the problems that have forced swimming pools to cease operation during the past five years.

Two of the reporting schools, or 5 per cent, closed their pool because of algae problems. The two pools were closed a total of four days or an average of two days.

TABLE XXI

FREQUENCY OF BACTERIAL COUNT IN THE SWIMMING POOLS OF THE FORTY REPORTING SECONDARY SCHOOLS IN IOWA

| Frequency of Bacterial Count | Number of Schools | Per Cent of Schools |
|---|---|---|
| Annually | 2 | 5 |
| Monthly | 6 | 15 |
| Weekly | 16 | 40 |
| Daily | 4 | 10 |
| Other | 12 | 30 |

TABLE XXII

CAUSES FOR DISCONTINUING OPERATION OF SWIMMING POOLS IN FORTY IOWA SECONDARY SCHOOLS

| Reason for Closing | Number of Schools | Per Cent of Schools |
|---|---|---|
| | (N = 40)* | |
| Algae | 2 | 5 |
| Chlorine Problems | 8 | 20 |
| Structural Problems | 9 | 22.5 |
| Drainage for Cleaning | 15 | 37.5 |
| Filter Problems | 14 | 35 |
| Other | 10 | 25 |

*Number totals more than forty due to multiple responses.

Chlorine problems caused eight, or 20 per cent, of the pools to close a total of sixteen and one-half days for an average of two days.

Structural problems, including the repair of under-water lights, repairs of steps and pool wall, accounted for a loss of eighteen days of pool time in nine schools.

Only fifteen, or 37.5 per cent, of the pools were drained for cleaning.

Filter problems accounted for the greatest number of closings. Fourteen institutions reported such malfunctions for a total of twenty-one days.

Ten schools have never drained their pools other than for cleaning purposes.

Other responses included loss of one day for human feces and one "can't remember why."

When a pool malfunctioned a number of sources were consulted. Ten schools contacted a plumber, nine called a consulting firm, ten asked for the services of an engineer and eight sought help from the manufacturer.

Other replies included two who consulted the "supervisor of operation and maintenance"; one who had the "chief engineer of the school district come in": two talked with "school maintenance"; five who answered "myself"; two who said "no one yet"; and one who specified an individual by name.

Fifteen maintenance personnel stated that their pools were never officially inspected by a professional firm. Ten pools were inspected on an annual basis, six on a semi-annual basis, four on a monthly basis and two on a weekly basis. The other two responses were "regularly" and "as needed."

## CHAPTER IV

## SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

### I. SUMMARY

It was the purpose of this study to determine whether or not the swimming pools in the secondary schools of Iowa were maintained in a manner that resulted their being hygienically safe.

This study involved the following aspects of pool maintenance: (1) information on the school pools and the background of the maintenance personnel surveyed, (2) time spent in swimming pool maintenance, (3) conditions in the swimming pool area, (4) condition of the swimming pool water, (5) filtration and disinfection of the swimming pool water, and (6) problems encountered in the operation of the swimming pools.

The study was accomplished by a questionnaire developed through a review of current literature. The questionnaire was validated by nine swimming pool maintenance personnel in the colleges and universities of Iowa. The final questionnaire was sent to forty-five secondary school swimming coaches and swimming instructors, who gave the forms to the persons responsible for swimming pool maintenance in their schools.

Forty, or 90 per cent, of those contacted returned the completed questionnaires.

## II. CONCLUSIONS

After tabulating the results of this study, a wide range of swimming pool maintenance procedures, ranging from pools that are very well maintained to those that illustrate careless maintenance, was observed.

It was the investigator's conclusion that, whereas at the present time the majority of the swimming pools in the forty reporting secondary schools are adequately maintained, there are areas of maintenance that deserve attention.

1. Over one-half of the maintenance personnel have not had any chemistry background, yet part of their job is that of the "pool chemist."
2. The swimming pool maintenance personnel in the forty secondary schools of Iowa have not had sufficient training to efficiently operate the pools. There was no definite method of training for maintenance personnel. Eleven personnel had no training whatsoever.
3. The majority of the maintenance personnel did not have a true understanding of their filter systems. Twenty-seven, or 77.5 per cent, were unable to designate the flow rate for which their pools had been designed.

## III. RECOMMENDATIONS

The following recommendations are based on needed improvements ascertained through the study of the problem.

1. The State Department of Public Instruction or State Department of Public Health should publish a manual of operation and maintenance. They should establish standards specifically for school swimming pools. This should be written in lay terms and updated at regular intervals.
2. The swimming pool maintenance personnel should familiarize themselves with operation methods and keep up with growing trends in swimming pool maintenance.
3. The State Department of Public Instruction should establish a curriculum in swimming pool maintenance, conduct schools or clinics and then certify swimming pool operators. This should be done annually because of a rapid turnover in swimming pool personnel.
4. The State Health Department should make an annual check of the sanitation enforcements prior to bathing and require a weekly water sample for testing the bacterial count.
5. The school administration should assign maintenance personnel to the swimming pool seven days a week and have a professional firm examine the swimming pool and equipment once a year.

There are fallacies in all areas of swimming pool maintenance in some schools. If the five preceding recommendations were put into effect, all aspects of swimming pool maintenance would be checked and these malfunctions could be corrected.

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# APPENDICES

# APPENDIX A

## Letter of Transmittal

Des Moines, Iowa
February 25, 1973

Dear Colleague:

The enclosed questionnaire is to be used to collect data for a research report, as a partial fulfillment of the requirement for the degree, Master of Science in Education at Drake University.

The purpose of this study is to determine what maintenance procedures are used in the swimming pools of the Secondary Schools of Iowa.

In order to assist me in this study, would you please give this questionnaire to the person responsible for the maintenance of your swimming pool and request that the questionnaire be completed and returned at the earliest convenience. It would be preferable if this questionnaire could be returned to me by March 15, 1973. Neither the names of the personnel nor the names of the schools will be reported.

A stamped envelope is enclosed to facilitate the return. Thank you for your prompt attention in completing and returning this questionnaire.

Yours truly,

Patricia A. Bloomcamp
Girls' Swimming Coach
Hoover High School
Des Moines, Iowa 50310

# APPENDIX B

## QUESTIONNAIRE

### Maintenance of Swimming Pools in the Secondary Schools of Iowa

This questionnaire has been developed to determine maintenance procedures in the swimming pools in Secondary Schools of Iowa.

Please read each statement carefully and respond with the answer or answers which best suit(s) the actual practice used. Please feel free to qualify any of your answers in the space below each statement.

To help maintain the validity of this study, please read and answer each question carefully and honestly.

1. What is your current responsibility in relation to the swimming pool?

    _____ Building Principal

    _____ Coach (Swimming)

    _____ Head Custodian

    _____ Pool Maintenance

    _____ Other ______________________________
    (Please specify)

2. How many years has your swimming pool been in operation?

    _____ Less than 1 year

    _____ 1 to 5 years

    _____ 6 to 10 years

    _____ 11 to 15 years

    _____ More than 15 years

3. How many years of experience have you had in swimming pool maintenance?

    _____ Less than 1 year

    _____ 1 to 5 years

_____ 6 to 10 years

_____ 11 to 15 years

_____ More than 15 years

4. How many years of chemistry, either high school or college, have you completed?

_____ One-half Year

_____ One Year

_____ Two Years

_____ More than Two Years

_____ None

5. How many days per week is a maintenance person assigned to the maintenance of the swimming pool?

_____ 7

_____ 6

_____ 5

_____ 4

_____ 3

_____ 2

_____ 1

6. Approximately how many hours per day are spent in maintenance of the swimming pool?

_____ Less than One

_____ One

_____ Two

_____ Three

_____ Other ______________________________
(Please specify)

7. Who taught you the operation of the swimming pool filter system?

_____ Professional Engineer

_____ Manufacturer

_____ Installer

_____ School Personnel

_____ None

8. How often do you swim in the pool?

_____ Annually

_____ Monthly

_____ Weekly

_____ Daily

_____ Never

9. Which of the following activities are carried out in your swimming pool?

_____ Instruction

_____ Competitive Swimming

_____ Recreational Swimming

_____ Therapeutic Work

_____ Synchronized Swimming

10. Which of the following are enforced before swimming?

_____ Shower

_____ Foot Bath

_____ Caps for Girls

_____ Caps for Boys with Long Hair

11. How is the air in the swimming pool room circulated?

_____ Continuously

_____ Intermittently

_____ Randomly

_____ Other _______________________________________________
(Please specify)

12. What type of air circulation is used in the swimming pool room?

_____ Air Conditioning

_____ Fans

_____ Open Windows

_____ None

_____ Other _______________________________________________
(Please specify)

13. Which of the following is the nearest to the air temperature you maintain?

_____ 70 degrees

_____ 75 degrees

_____ 80 degrees

_____ 85 degrees

_____ Other _______________________________________________
(Please specify)

14. Which of the following is the nearest to the water temperature you maintain?

_____ 70 degrees

_____ 75 degrees

_____ 80 degrees

_____ 85 degrees

_____ Other _______________________________________________
(Please specify)

15. What type of filter system does your swimming pool use?

_____ Sand (Pressure)

_____ Sand (Gravity)

_____ Diatomaceous Earth (Vacuum)

_____ Diatomaceous Earth (Pressure)

_____ None

_____ Other ______________________________
(Please specify)

16. Which of the following flow rates per square foot of filter area is your swimming pool designed for?

_____ 1

_____ 2

_____ 3

_____ 4

_____ More

17. Which of the following equipment is used for disinfecting purposes?

_____ Gas Chlorinator

_____ Hypo-chlorinator

_____ Brominator

_____ Saturator

_____ Other ______________________________
(Please specify)

18. What disinfectant is used?

_____ Bromine

_____ Chlorine

_____ Iodine

_____ Ozone

_____ Other ______________________________
(Please specify)

19. How often is the swimming pool water tested?

_____ Weekly

_____ Daily

_____ Twice Daily

_____ Three Times Daily

_____ Other ______________________________
(Please specify)

20. Which of the following is the nearest to the pH reading you maintain?

_____ 6.6

_____ 7.0

_____ 7.6

_____ 8.0

_____ Other ______________________________
(Please specify)

21. What disinfectant residual is the nearest to that which you maintain?

_____ .0

_____ .5

_____ 1.0

_____ 2.0

_____ Other ______________________________
(Please specify)

22. How often is the disinfectant applied?

_____ Continually

_____ Twice Daily

_____ Daily

_____ Weekly

_____ Other ______________________________
(Please specify)

23. How often is the swimming pool water chemically adjusted?

_____ Twice Daily

_____ Daily

_____ Twice Weekly

_____ Weekly

_____ Other ______________________________
(Please specify)

24. How is your swimming pool floor cleaned?

_____ Vacuum

_____ Brush

_____ Scuba Diver with Brush

_____ Not Cleaned

_____ Other ______________________________
(Please specify)

25. How often is your swimming pool floor cleaned?

_____ Daily

_____ Weekly

_____ Monthly

_____ Other ______________________________
(Please specify)

26. How often is your swimming pool deck cleaned?

_____ Daily

_____ Twice Weekly

_____ Weekly

_____ Monthly

_____ Other ______________________________
(Please specify)

27. How is your swimming pool deck cleaned?

_____ Hose

_____ Mop

_____ Brush

_____ Disinfectant

_____ Other ______________________________
(Please specify)

28. How often is the bacterial count checked?

_____ Annually

_____ Monthly

_____ Weekly

_____ Daily

_____ Other ______________________________
(Please specify)

29. Who examines the bacterial count in the swimming pool?

_____ Federal Agency

_____ State Agency

_____ City Agency

_____ School District Agency

_____ Other ______________________________
(Please specify)

30. How often is the swimming pool officially inspected by a professional firm?

_____ Annually

_____ Semi-annually

_____ Monthly

_____ Weekly

_____ Other ______________________________
(Please specify)

31. How many days during the past five years has your swimming pool been forced to cease operation other than for cleaning?

_____ 0

_____ 1 - 5

_____ 5 - 10

_____ 10 - 15

_____ Other ______________________________
(Please specify)

32. For what reasons and the number of times has your swimming pool been closed to swimmers? (Please specify number of times).

_____ Algae

_____ Chlorine Problems

_____ Structural Problems

_____ Drainage for Cleaning

_____ Filter Problems

_____ Other ______________________________
(Please specify)

33. If the swimming pool malfunctions, whom do you secure for repairs?

_____ Plumber

_____ Consulting Firm

_____ Engineer

_____ Manufacturer

_____ Other ______________________________
(Please specify)

# APPENDIX C

## List of Secondary Schools with Pools

A questionnaire regarding the maintenance of the swimming pools in the Secondary Schools of Iowa was sent to the swimming coach or swimming instructor in the following schools:

Boone High School

Britt High School

Cedar Falls, University of Northern Iowa High School

Cedar Rapids, Jefferson High School

Cedar Rapids, Kennedy High School

Cedar Rapids, Washington High School

Clinton High School

Council Bluffs Woodrow Wilson Junior High School

Davenport, Central High School

Davenport, West High School

Des Moines, East High School

Des Moines, Hoover High School

Des Moines, Lincoln High School

Des Moines, North High School

Des Moines, Roosevelt High School

Des Moines, Technical High School

Dubuque, Hempstead High School

Evansdale, Bunger Junior High School

Fort Dodge, North Junior High School

Fort Dodge, South Junior High School

Gladbrook High School

Jesup High School

Marshalltown High School

Marshalltown, Junior High School

Mason City, Roosevelt Junior High School

Mason City, Monroe Junior High School

Middle Amana, Lakeside High School

New London High School

Oelwein, New Junior High School

Oskaloosa High School

Sac City High School

Sioux City, East High School

Sioux City, North High School

Sioux City, West High School

Southeast Polk High School

Tipton High School

Waterloo, Central High School

Waterloo, East High School

Waterloo, Edison School

Waterloo, Hoover Junior High School

Waterloo, Logan Junior High School

Waterloo, McKinstry Junior High School

Waterloo, West High School

West Des Moines, Valley High School

Williamsburg High School